

**LASER RETROREFLECTORS FOR: DYDIMOS, COMETS, PHOBOS, DEIMOS, CLPS AND LUNAR LAGRANGIAN L1 FOR EXPLORATION, PLANETARY AND GRAVITY SCIENCES.** S. Dell’Agnello<sup>1</sup>, G.O. Delle Monache<sup>1</sup>, L. Porcelli<sup>1,2</sup>, M. Tibuzzi<sup>1</sup>, L. Salvatori<sup>1</sup>, C. Mondaini<sup>1</sup>, M. Muccino<sup>1</sup>, M. Di Paolo Emilio<sup>1</sup>, R. March<sup>1</sup>, L. Ioppi<sup>1</sup>, O. Luongo<sup>1</sup>, S. Casini<sup>1</sup>, G. Bianco<sup>1,3</sup>, D. G. Currie<sup>4</sup>, R. Vittori<sup>1,5</sup>, C. Benedetto<sup>3</sup>, F. Pasquali<sup>3</sup>, M. Petrassi<sup>1</sup>, L. Filomena<sup>1</sup>, L. Mauro<sup>1</sup>, L. Rubino<sup>1</sup>, V. Sanclementi<sup>1</sup>, <sup>1</sup>Istituto Nazionale di Fisica Nucleare–Laboratori Nazionali di Frascati (INFN–LNF), Via E. Fermi 40, 00044, Frascati, Italy (simone.dellagnello@lnf.infn.it); <sup>2</sup>Dipartimento di Fisica, Università della Calabria (UniCal), Via P. Bucci, 87036, Arcavacata di Rende, Italy; <sup>3</sup>Agenzia Spaziale Italiana–Centro di Geodesia Spaziale “Giuseppe Colombo” (ASI–CGS), Località, Terlecchia 75100, Matera, Italy; <sup>4</sup>University of Maryland (UMD) at College Park, MD, USA; <sup>5</sup>Italian Air Force, Rome, Italy, ASI and Embassy of Italy in Washington DC.

**Abstract.** We will describe several payload models of next-generation laser retroreflectors that we developed for the diverse exploration, planetary and gravity sciences of: Asteroids and Comets, the Phobos-Deimos system, NASA’s CLPS program (Commercial Lunar Payload Services), the Earth-Moon Lagrangian point L1 and cislunar orbits, including applications to the LOP-G (Lunar Orbital Platform and Gateway).

Diverse and specific payload design, prototyping [1] and space testing [2] activities were completed in the period 2016-2018 by INFN-LNF (Frascati, see also ([www.lnf.infn.it/esperimenti/etrusco/](http://www.lnf.infn.it/esperimenti/etrusco/))) and ASI-CGS (Matera), in the framework of the: Joint Laboratory between INFN-LNF and ASI-CGS; Affiliation of INFN to NASA/SSERVI (Solar System Exploration Virtual Institute); Association of ASI to SSERVI; activities funded by the INFN National Science Committees n. 5 (CSN5, mainly devoted to technology research) and n. 2 (CSN2, mainly devoted to space sciences) [1]. These payloads and their applications are summarized in the following.

- COSPHERA = COMet/asteroid SPHERical laser Retroreflector Array. This payload is intended for observation from the proposed ESA Hera mission (evolution of the AIM, Asteroid Impact Mission) to the Didymos double asteroid. The Hera design includes a lidar capable of laser-ranging/altimetry. For Hera we have designed and built multiple Italy-branded miniaturized payloads, COSPHERA and others. These payloads inherit from the proven technologies space qualified for ASI, ESA and NASA-JPL for the Martian microreflectors onboard the ESA ExoMars missions, and the NASA InSight and Mars 2020 missions.
- PANDORA = Phobos AND DeimOS laser Retroreflector Array. This payload is intended for observation from orbiters capable of laser-ranging/altimetry in the Mars systems, like the Martian Moons eXploration (MMX) mission of the Japan Aerospace Exploration Agency (JAXA).

- MoonLIGHT-100/NGLR = Moon Laser Instrumentation for General relativity High accuracy test (INFN-LNF)/Next Generation Laser Retroreflector (UMD). This 100 mm single, large reflector is intended for direct lunar laser ranging from stations in USA, Italy (ASI-CGS) and France (Grasse). Its main applications are the Lunar Geophysical Network (LGN) and precision tests of General Relativity (GR) [3] and new theories of fundamental relativistic gravity [4]. Current analysis of GR and new physics in the sun-Earth-Moon systems will be presented.
- LaGrEx = Lagrangian point Gravity Explorer. This 75 mm single, medium-large laser retroreflector is a reduced mass/volume backup payload for CLPS landings and is designed for accurate laser positioning in the Earth-Moon Lagrangian point L1 (for the test of gravity in L1 see [5]).

These payloads are available for application of laser positioning of the LOP-G and other cislunar orbits.

#### References:

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